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(54) Display device.

(57) When an active matrix LCD is driven while using inversion per n rows (n ≥ 2), stripe effects occur. In the case of double line inversion this leads to stripes in the picture. According to the invention this can be largely obviated by giving at least the last row of the rows in a group of n rows a different selection voltage.

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The invention relates to a display device comprising a system of pixels arranged in rows and columns and a line selection circuit which can select rows of pixels by means of selection voltages during operation, the device also comprising a circuit for presenting column or data voltages during selection.

A display device of this type is suitable for displaying alpha-numerical information and video information by means of passive electro-optical display media such as liquid crystals, electrophoretic suspensions and electrochromic materials.

A display device of the type described in the opening paragraph is known from European Patent Application no. 0 299 546 (PHN 12.154) laid open to public inspection, in the name of the Applicant. This Application describes a drive mode providing the possibility of charging the pixels in such a way that pixels in consecutive rows are charged at the opposite polarity (single row inversion) and the polarity in different frames is inverted (frame inversion), while there is a considerable freedom of choice as regards the form of colour filters which may be used.

When using some colour filters, it may be advantageous to invert the polarity, for example, after driving every two rows (double row inversion) instead of one row. Asymmetries in picture electrodes or technical reasons regarding layout may also give rise to a repetition of certain patterns after, for example, four rows so that it may be favourable to repeat the inversion after every four rows or, more generally, after m rows.

When such display devices are used, stripes are usually visible along the edge of the groups of rows. In the case of double row inversion this becomes manifest in light rows alternating with dark ones.

The present invention has, *inter alia*, for its object to provide a display device in which said stripe effects are reduced considerably.

To this end a display device according to the invention is characterized in that the line selection circuit can select consecutive rows of pixels within groups of at least two rows of pixels during operation and charges consecutive groups of pixels in the opposite sense, the line selection circuit being capable of applying a selection voltage to at least one row electrode or selection electrode at the beginning or the end of a group of rows during operation, which selection voltage differs from the other selection voltages within the group.

The invention is based on the recognition that said stripe effects are mainly due to capacitive couplings between consecutive rows.

In the case of such an inversion after, for example, m rows the first row of pixels in a subsequent group is charged in the opposite sense with respect to the pixels in the previous group. This effect can be corrected to some extent by adapting the selection voltages at one side or at both sides at the transition of a group of pixels to a subsequent row. Since the correction also depends on the capacitance of the pixel, which in its turn depends on the setting of this pixel on the transmission/voltage characteristic curve, the correction is preferably performed for a pixel capacitance which corresponds to a setting halfway the transmission/voltage characteristic curve (medium grey).

The invention is notably suitable for colour display devices, using a colour filter whose colour pixels of one and the same colour in consecutive rows are shifted with respect to each other by one or more columns. In the case of single row inversion similar colour pixels would always be charged in the same direction, so that crosstalk of the column signal *via* the capacitive division of the capacitances of the pixel and of a non-linear switching element (diode, MIM) may have a detrimental effect (notably in larger areas of one and the same colour). By division into groups of two (double row inversion), with the possible exception of rows at the edge (of the display), this crosstalk problem (between columns and rows) is largely solved, but a capacitive coupling between the row electrodes becomes visible in the form of said stripe effects. The adaptation, according to the invention, of the selection voltages reduces the occurrence of these stripes.

The picture electrodes may be switching units consisting of one or more active switching elements. The switching elements may be two-poles (for example, diodes, MIMs) or three-poles (for example, thin-film transistors (TFTs)).

The invention will now be described in greater detail with reference to some embodiments and the drawing in which

Fig. 1 is a cross-sectional view of a display device embodying the invention,

Fig. 2 shows a part of Fig. 1 on a larger scale,

Fig. 3a is a diagrammatic plan view of a colour filter, with reference to which the above-mentioned problems occurring in the case of single row inversion are explained,

Fig. 3b is a diagrammatic plan view of a similar colour filter, with reference to which the invention will be further described,

Fig. 4 shows diagrammatically a part of the display device according to the invention and

Fig. 5 shows equivalent circuit diagrams, with respect to which aspects of the invention will be described, while

Fig. 6 shows a part of the row signals for one of the drive modes.

Fig. 1 shows in a diagrammatic cross-section a

part of a display device, in this embodiment a liquid crystal display device 1, comprising two supporting plates 2 and 3 between which, for example, a twisted nematic liquid crystalline material 4 is present. The inner surfaces of the supporting plates 2 and 3 are provided with electrically and chemically insulating layers 5. A number of row and column-arranged picture electrodes 6 of indium-tin oxide or another electrically conducting transparent material is provided on the supporting plate 2. Transparent picture electrodes 7 of, for example, indium-tin oxide which are integrated to strip-shaped electrodes (in this embodiment column electrodes) are also provided on the supporting plate 3. The facing picture electrodes 6, 7 constitute the pixels of the display device.

Strip-shaped (for example, metal) row electrodes 8 are arranged between the rows of picture electrodes 6. Each picture electrode 6 is connected to a row electrode 8 *via* a switching element (not shown). Furthermore, liquid crystal orienting layers 10, 18 are provided on the inner surfaces of the supporting plates 2 and 3. As is known, a different orientation state of the liquid crystal molecules and hence an optically different state can be obtained by applying a voltage across the liquid crystal layer 4. The display device can be realised as a transmissive or a reflective device and may have one or two polarizers.

In Fig. 2 the cause of the capacitive coupling will be further explained. A stray capacitance C_c, which is diagrammatically illustrated by means of the field line 9, is produced *via* the substrate 2 of, for example, glass. The picture electrode 6^a associated with the first pixel 11^a receives a voltage of, for example, $-V_c$ after selection. If the picture electrode 6_b associated with the next pixel also receives a voltage $-V_c$ in a subsequent selection period after it has received a voltage of $+V_c$ in a previous (frame or field) period (the transmission value of juxtaposed pixels, notably in large areas, is often closely correlated), the voltage across the picture electrode 6^b changes from $+V_c$ to $-V_c$. Such a voltage variation of $2V_c$ of this picture electrode causes a voltage variation *via* the capacitance C_c across the pixel associated with picture electrode 6^a by a value of $\Delta V = (C_c/(C_p+C_c+C_m))*2V_c$, or roughly $(C_c/C_p)*2V_c$. C_p is the capacitance of the pixel and C_m is the capacitance of the non-linear switching element (see also Fig. 5).

The absolute value of the voltage across the first picture electrode increases when the second picture electrode is charged in the same direction and the first pixel becomes darker (based on a twisted nematic liquid crystal effect between crossed polarizers). However, if a third, subsequent pixel receives an opposite charge, the absolute value of the voltage across the second pixel will be smaller than is intended so that this pixel becomes lighter. In the case of double row inversion the first row of each pair of rows in which the pixels are charged in the same direction becomes darker and the second row becomes lighter than is intended. In the case of inversion after larger numbers of rows this effect always occurs around the last row of the blocks into which the rows have been divided.

Fig. 3a is a diagrammatic plan view of a plurality of pixels 11 of a colour display device with a colour filter whose colour elements (corresponding to pixels) in juxtaposed rows are shifted with respect to each other over half a pitch. When single row inversion is used, in which the above-mentioned capacitive crosstalk is largely corrected in monochrome display devices, pixels of the same colour in one column are always charged with the same sign. In Fig. 3a this is denoted by means of a + or a - sign. Since, for example, consecutive red pixels in the same column are always charged in the same direction, crosstalk *via* the capacitive division of the capacitances associated with the non-linear switching element and the pixel (having a value of

$$\frac{C_m}{C_m+C_p+C_c}\Delta V_k$$

ΔV_k: voltage sweep on the column) causes a setting on the transmission/voltage characteristic curve which gives a too high or too low transmission for a given colour in one column.

In the case of double row inversion (Fig. 3b) successive pixels of one and the same colour in the same column are charged in the opposite sense, but now the capacitive coupling of the rows produces the above-mentioned stripe effect. According to the invention this can at least partly be obviated by the choice of the row or selection voltages.

This will be further explained with reference to Fig. 4. The display device shown in this Figure comprises a plurality of pixels 11 arranged in rows and columns which are driven *via* switching elements 12, for example, MIMs (metal-isolator-metal). By successively selecting (energizing) row electrodes 8, information which is present on the column electrodes 7 is presented to the pixels 11. Row electrodes 8 are consecutively selected by means of, for example, a row selection circuit 13, while the information to be presented for a selected row of pixels is stored in a register 15. The assembly is driven and synchronized by means of the switching unit 15. In this embodiment the rows are

divided into groups of two, with the possible exception of the first and the last row, *i.e.* a display device comprising n rows of pixels is then divided into at least (n-2)/2 groups of two rows of pixels.

Fig. 5a shows a part (three pixels) of the device of Fig. 4 in which the stray capacitance C_c is shown by means of broken lines. If the pixels 11^a and 11^b are consecutively charged positively (double line inversion) by means of selection voltages on the row electrodes 8^a, 8^b and if subsequently pixel 11^c is charged negatively by selecting row electrode 8^c, the voltage across pixel 11^b is decreased. According to the invention this is prevented by choosing the selection voltage across the row electrode 8^a (hence 8^c ...) to be lower, or by choosing the voltage across the row electrode 8^b to be higher; a combination is alternatively possible. In the relevant embodiment in which the row electrodes are divided into groups of two the selection voltages within each group of two are thus different. The correction to be set is also dependent on the setting on the transmission/voltage characteristic curve and is preferably set at a value halfway this characteristic curve (medium grey).

The device of Fig. 4 can also be driven by means of the method as described in EP-A-0 362 939 (PHN 12.698) which is herein incorporated by reference. Fig. 6 shows diagrammatically the associated selection signals (5-level drive) for two successive rows. If a row is charged positively, which corresponds to a selection voltage V_{s1} in Fig. 6, the variation of the voltage across picture electrode 6 (medium grey) is $-2V_c = -(V_{sat}+V_{th})$(this value also applies to the previous example; V_{sat}: saturation voltage, V_{th}: threshold voltage), which corresponds to a negative feedback to the picture electrode in the previous row. If the row is charged negatively, the reset voltage V_{res} is first applied to a row electrode. This does not have any influence on the picture electrode in the previous row because this row receives a selection voltage V_{s2} at that moment and consequently the non-linear switching element is still conducting (time interval t1 in Fig. 6). Picture electrode 6 is charged to a voltage of at least $V_{sat}+1/2(V_{sat}-V_{th})$ at the end of the reset period. At the end of the next selection period the voltage (in the case of medium grey) is $\frac{1}{2}(V_{sat}+V_{th})$ resulting in a net variation of $\geq -(V_{sat}-V_{th})$ across the picture electrode in the previous row. This negative feedback is smaller than in the case of 4-level drive so that the selection voltages are chosen to be slightly different than in the previous embodiment in which the feedback has substantially the same value in both cases.

For the devices of Fig. 5b and 5c slightly different considerations are used with respect to the values of the voltage variations across the picture electrodes, but here again stripe effects can be largely prevented by adapting one or more selection voltages within a group of rows in the case of double row inversion, or more generally, inversion after m rows.

The invention is of course not limited to the embodiments described but several variations are possible within the scope of the invention. The stray capacitance, which causes said capacitive coupling between the rows, does not only exist in devices with two-poles as shown in the Figures but also in active pixels based on three-poles such as TFTs so that the invention is also applicable in this field. In the case of a division of the rows into larger groups the stray capacitance to a picture electrode which is further remote may be taken into account, if necessary, in the adaptation of the selection voltages.

Claims

1. A display device comprising a system of pixels arranged in rows and columns and a line selection circuit which can select rows of pixels by means of selection voltages during operation, the device also comprising a circuit for presenting column or data voltages during selection, characterized in that the line selection circuit can select consecutive rows of pixels within groups of at least two rows of pixels during operation and charges consecutive groups of pixels in the opposite sense, the line selection circuit being capable of applying a selection voltage to at least one row electrode or selection electrode at the beginning or the end of a group of rows during operation, which selection voltage differs from the other selection voltages within the group.

2. A display device as claimed in Claim 1, characterized in that it comprises a colour filter whose colour pixels of one and the same colour in consecutive rows are shifted with respect to each other by one or more columns.

3. A display device as claimed in Claim 1 or 2, characterized in that the rows are divided into groups of two, with the possible exception of the first and the last row.

4. A display device as claimed in Claim 1, 2 or 3, characterized in that the picture electrodes are connected to the rows or columns *via* active switching units.

5. A display device as claimed in Claim 4, characterized in that the active switching unit comprises one or more two-poles or three-poles.

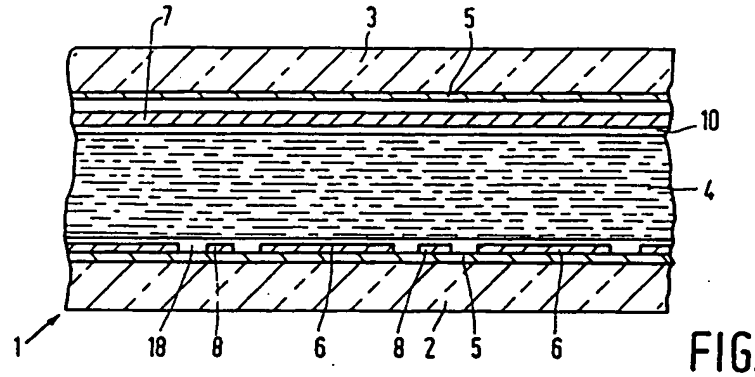

FIG.1

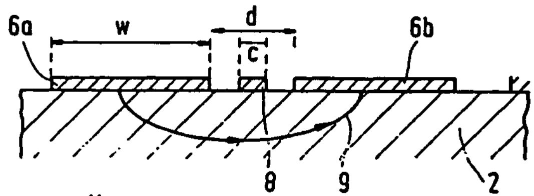

FIG.2

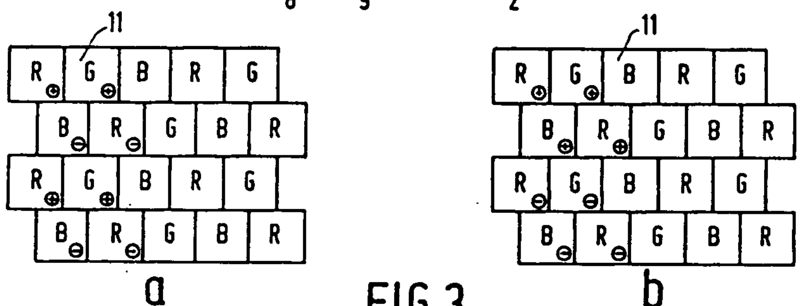

FIG.3

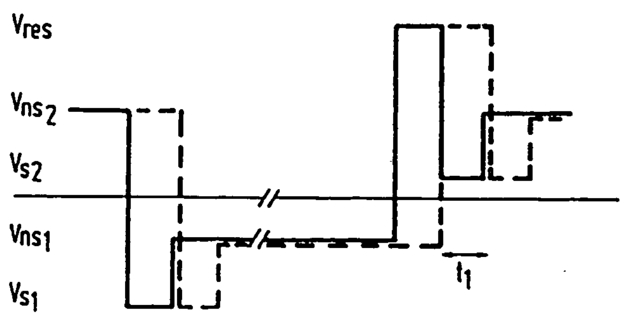

FIG.6

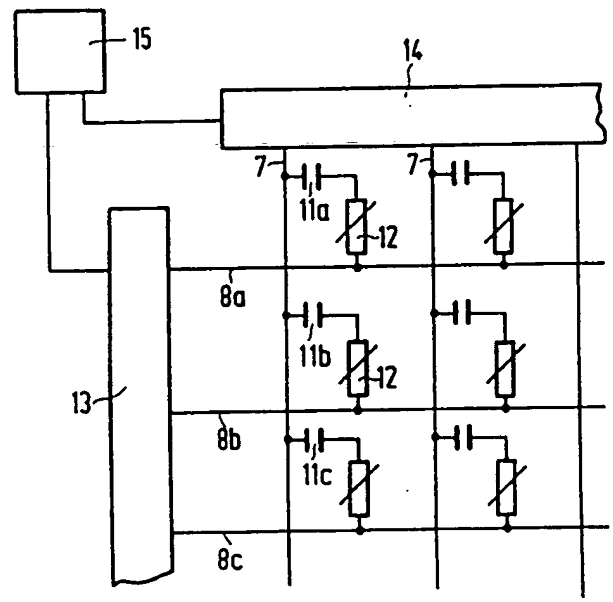
15
14
7
7
11a
12
8a
11b
12
13
8b
11c
8c

FIG.4

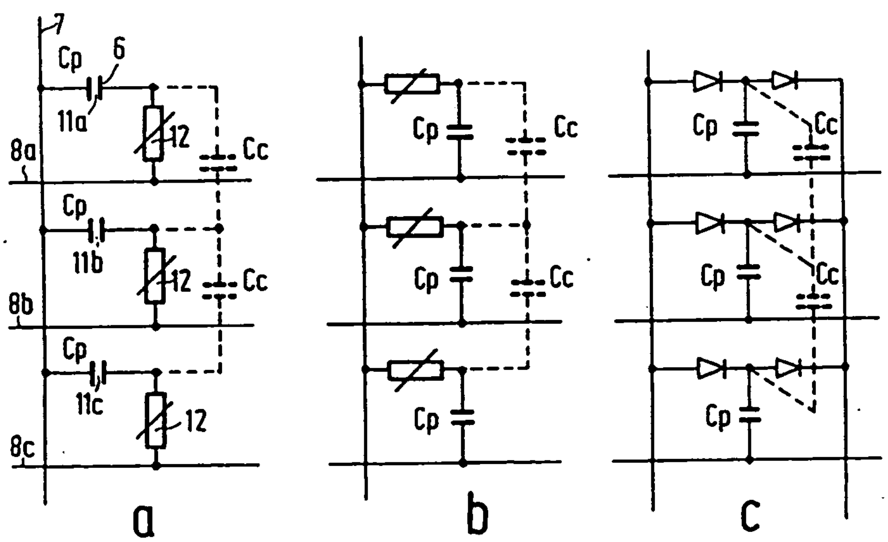
7
Cp
6
11a
12
Cc
8a
Cp
11b
12
Cc
8b
Cp
11c
12
8c
a
Cp
Cc
Cp
Cc
Cp
b
Cp
Cc
Cp
Cc
Cp
c

FIG.5

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 92 20 1992

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	EP-A-0 295 802 (SHARP KABUSHIKI KAISHA) * abstract; figure 5 * * column 2, line 19 - column 3, line 25; figure 11 * ---	1,3-5	G09G3/36
P,Y	EP-A-0 479 552 (SHARP KABUSHIKI KAISHA) * abstract; figure 7 * * column 1, line 39 - column 3, line 14 * * column 4, line 49 - column 5, line 31 * ---	1,3-5	
A	PROCEEDINGS OF THE SID. vol. 30, no. 3, 1989, NEW YORK US pages 259 - 262 , XP000115848 SHIGETO KOHDA 'A DEFECT-TOLERANT ACTIVE-MATRIX CIRCUIT AND HIS APPLICATION TO A HIGH-RESOLUTION COLOR LCD' * figures 1,4 * -----	2,4,5	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

G09G

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	13 NOVEMBER 1992	VAN ROOST L.L.A.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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E : earlier patent document, but published on, or after the filing date
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